Project ID # EEMS007

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Mobility Data and Models Informing Smart Cities

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2018 ANNUAL MERIT REVIEW

JUNE 20, 2018

Argonne NATIONAL LABORATORY | INL Idaho National Laboratory | BERKELEY LAB | OAK RIDGE National Laboratory | NREL NATIONAL RENEWABLE ENERGY LABORATORY

Overview

Timeline

- Project start date: 10/01/2016
- Project end date: 9/30/2019
- Percent complete: 50%

Budget

- Total project funding
  - DOE share: $1.655 M FY17–FY19
- Funding for FY 2017: $220k
- Funding for FY 2018: $220k

Barriers

- High-quality data for integration, visualization, analytical/data insights for advances in model outputs (e.g., person miles /vehicle miles traveled)
- Technology & service advances; new behaviors; mobility-as-a-service data

Partners

- DOE Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Lab Consortium
  - NREL: National Renewable Energy Lab
  - INL: Idaho National Lab (*Primary Collaborator)
  - LBNL: Lawrence Berkeley National Lab
  - ORNL: Oak Ridge National Lab
  - ANL: Argonne National Lab
- Associated Labs
  - LANL: Los Alamos National Lab
  - PNNL: Pacific Northwest National Lab
- US DOT Smart city challenge finalists
  - Respective university researchers in these cities (e.g. Carnegie Mellon University)
- Key City Data/Modeling Communities
  - Cities, MPOs, DOTs, Utilities, Transit, MaaS

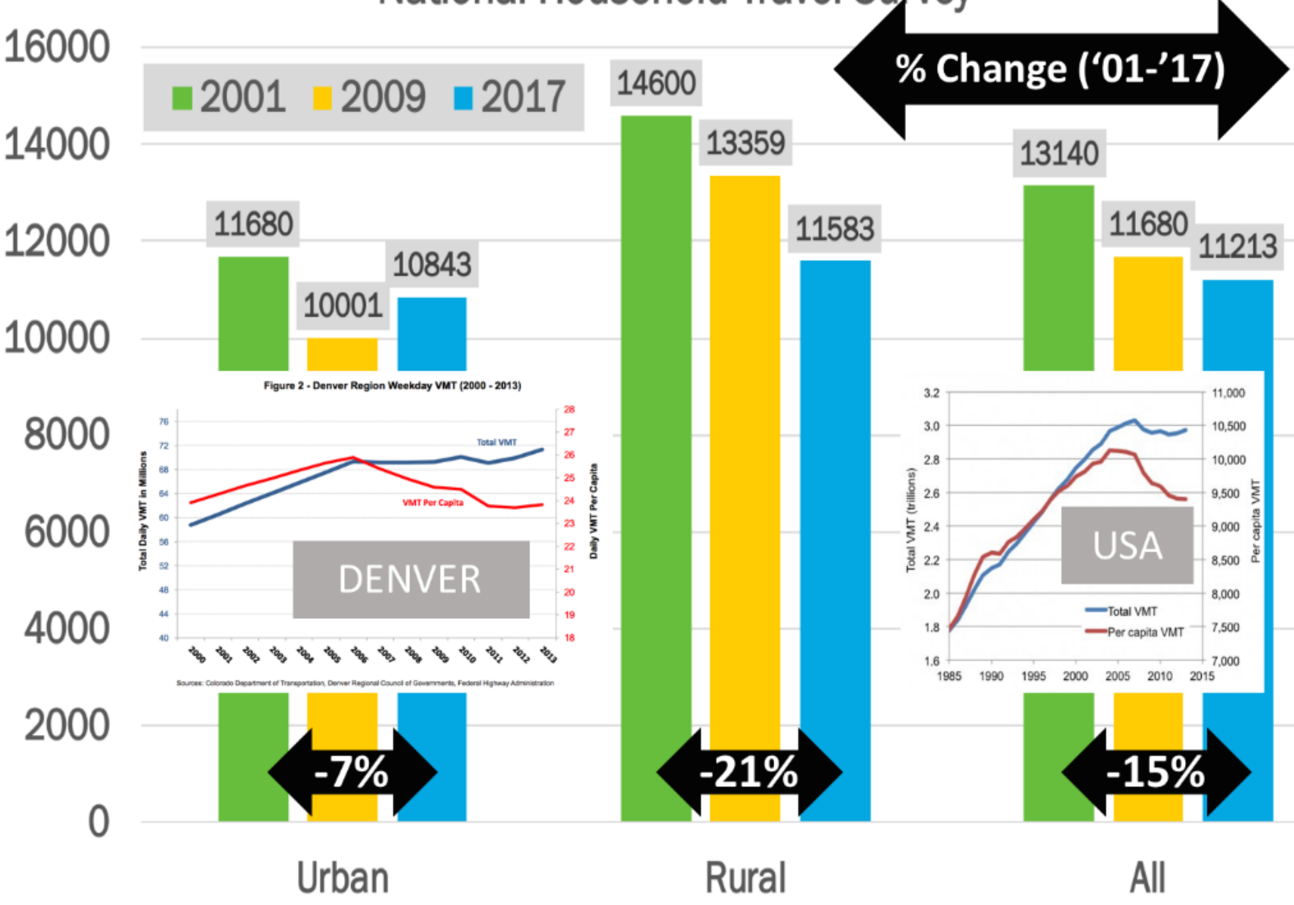
MPO: metropolitan planning organization, DOT: Department of Transportation, MaaS: mobility-as-a-service, PMT: person miles traveled, VMT: vehicle miles traveled

Relevance: CASES Enabling Energy-Efficient Mobility System Transitions, Transformations, and (R)evolutions for People in Cities

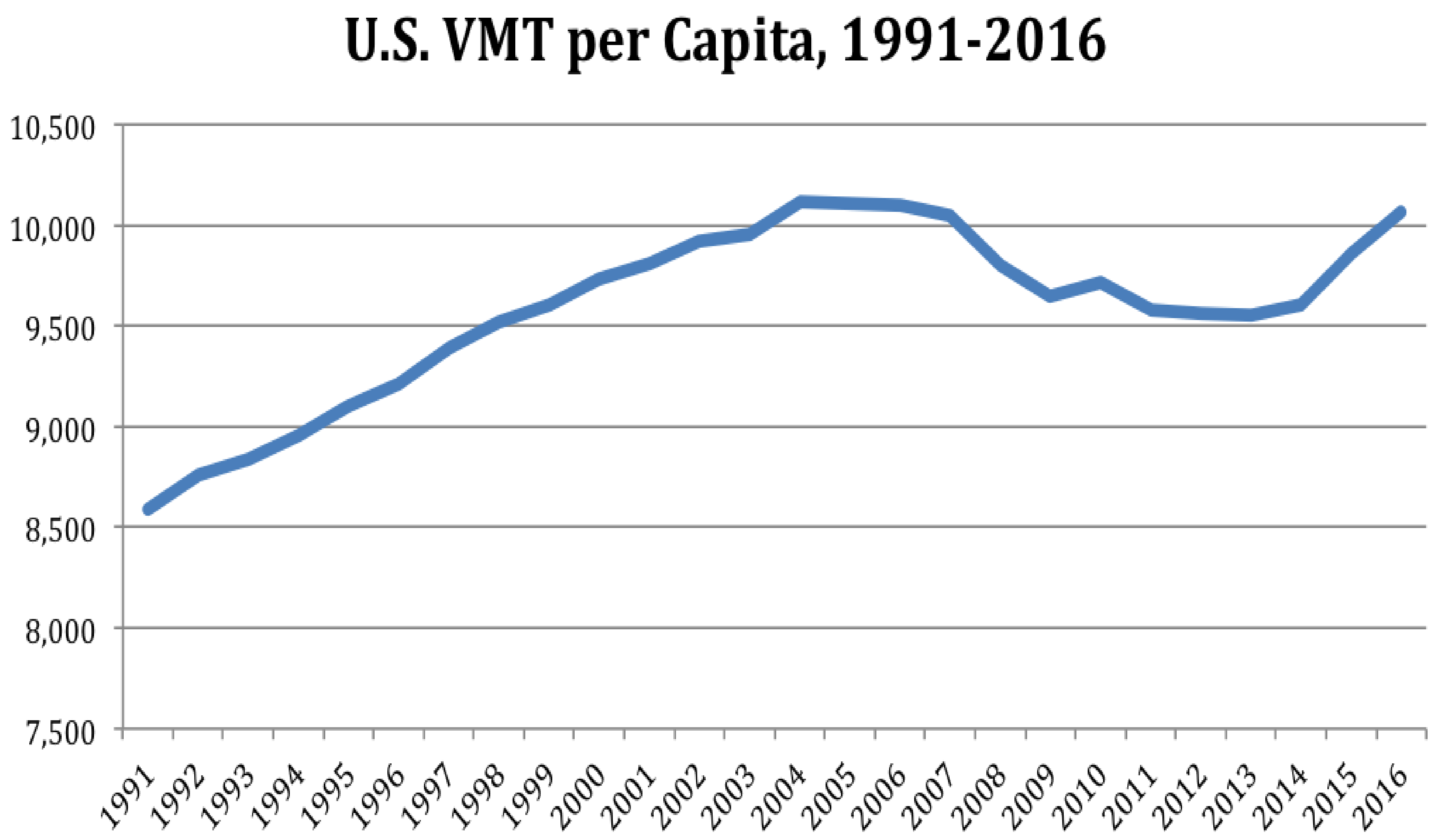
On the Cusp of Changes:

- → **Connected-Automated-Shared-Electrified services** are diffusing the fastest in cities (Sperling et al. 2017)
- → **Mobility data and models in cities inform scale/pace of impacts and transitions,** in response to disruptive technologies and services (Henao & Sperling, 2018)
- → **Mobility already changing fast** – a need for integrated urban & decision sciences (Duvall, Hou, Garikapati, Sperling, Young 2018)
- → **Digitally-enabled sharing services:** 2 of 3 globally willing to share/rent assets

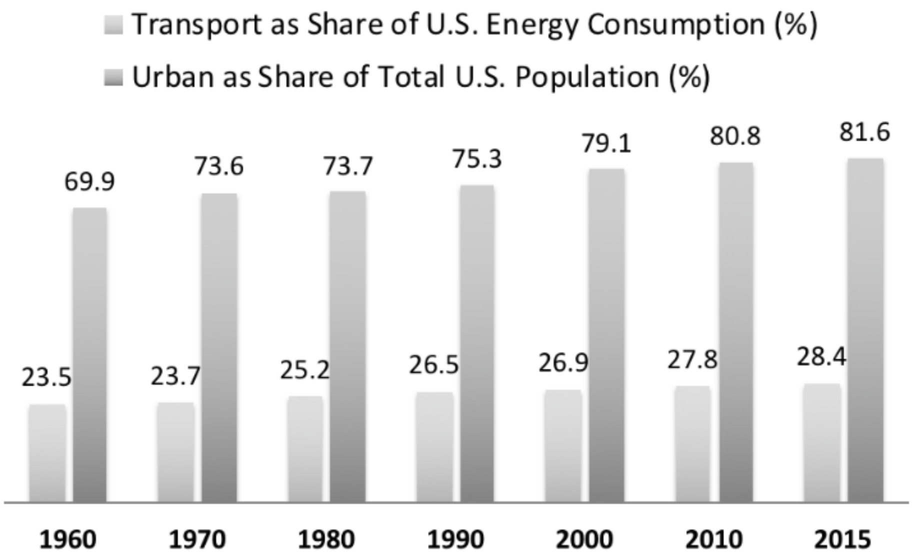
Average Annual Miles Driven (per Driver): National Household Travel Survey



Relevance: Alternative Urban Futures May Drive Significant Implications for Energy Efficient Mobility Systems and Services



Relevance: Co-Designing Analyses on CASES impacts on Mobility and Energy in Cities - e.g. Boston Airport from 2000 to 2014



[Sources: Adapted from US DOT/Census]

Boston Logan International Airport : *'New England's Largest Transportation Center '*

- 31.6 million passengers in 2014
- 17,000 airport employees
- $13 billion in annual economic activity

- **Key Message:** Urban/Transport Energy and VMT increases in U.S.— not fighting this—yet a critical need for:
  - Energy efficiency and productivity goals, performance metrics to move people + goods in least intense way
  - e.g., metrics of PMT/BTU or PMT/VMT (maximizing mobility); BTU/ton miles (if multi-modal or freight); or multi-criteria index?

From fewer air planes , carrying more people:

- In 2014, over 86,000 passengers were carried on 1000 flights per day
- In 2000, 76,000 passengers were carried on about 1300 flights per day

to fewer energy inputs to move more people faster, cheaper, safer, and w/ greater access?

Task Objectives: Three Key Analysis Activities to Fill Key Gaps

- **TNC/MaaS Analysis**
- **City / State Vehicle Registration Analysis**
- **Benchmark and analyze progress/ disruptions with annual industry or smart city survey**

TASK: 2.1 Urban Traveler – Changes and Impacts
SubTask: 2.1.1 Mobility Data and Models Informing SMART Cities
PILLAR: Urban Science **PI:** Josh Sperling (NREL)

U.S. DEPARTMENT OF ENERGY SMARTMOBILITY

•**Objective**: To provide objective and quantifiable data that fills key knowledge gaps and can be used in modeling/analysis efforts that address questions on how SMART technologies (ACES) impacts urban networks, travelers, and energy. Key research question/s include:

•How will ACES impact diverse urban travelers, systems, & services?

•Long-term energy/travel impacts from changing urban environments?

Approach:

• TNC /MaaS data collection & analysis at major mobility hubs, such as airports and other key destinations, to characterize mobility/energy impacts using novel collection methods that will circumvent relying directly on TNC companies for data informing critical analysis insights.

• Obtain direct access to state vehicle registration databases to characterize mobility/energy/behavioral impacts from EVs, AVs, other advanced tech & alternative fuels adoption – overcoming commercial license restrictions and obtaining highest possible detail & resolution.

•Collaborate with industry (Strategic Vision) on Smart City survey to assess/ benchmark/predict MaaS in cities potential, adoption rate, and Smart City questions at district/urban scales.

Milestones/Deliverables:

•Q1 – Issues requests / collect data for Airport operations

•Q2 - NDA/MOU for collaboration with industry yearly urban survey

•Q3 - Processed registration records from sample states

• Year End – Combined report

Outcomes/Impact:

• Direct observability into TNC and MaaS adoption for travel and behavioral models – critical to SMART.

• Freely sharable vehicle adoption patterns as revealed from state vehicle reg databases.

• Standard/OTS survey data accessible to researchers and Smart Cities.

Task Summary	
New/Continuing:	Continuing
Proposed Funding:	$220K for FY18 & 19
Lead Lab(s):	NREL, INL
Other Participants:	Collaboration with Strategic Vision, Airports, & State Motor Vehicle Bureaus
Interdependencies:	Output -> Airport TNC data & vehicle registration data to MDS 2.2.1, US 2.1.2, 2.1.3 & 2.2.1, and other TDM activities
Models / Tools:	Human-centered city data to inform new inputs/applications of behavioral models &TDM (Beam, Polaris, AMD toolkit, etc.)
Priority:	Critical

Lab	FY16	FY17	FY18	FY19	TOTAL
ANL					$ -
INL			$ 70	$ 70	$ 140
LBNL					$ -
NREL			$ 150	$ 150	$ 300
ORNL					$ -
PNNL					$ -
LANL			$ -	$ -	$ -
TOTAL	$ -		$ 220	$ 220	$ 440

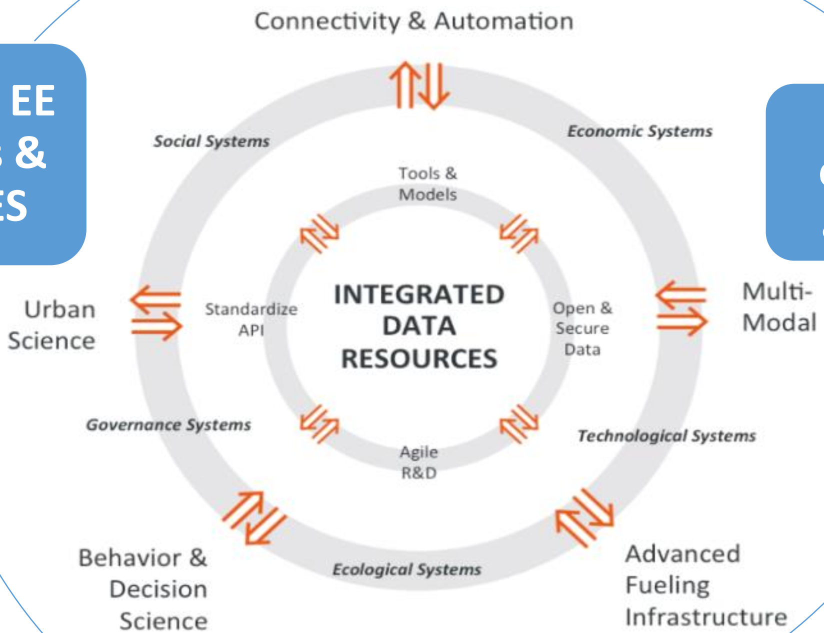
BASE LEVEL FUNDING FY18: $220K

Relevance: Maximum Mobility Energy for Smart City Futures… Urban Travel/Energy Impacts of Mobility Technologies & Services?

Provide new data (TNCs, CAVs, EVs)

ID key EE levers & CASES

Integrate existing data across siloes



Analyze DOE + city-relevant questions

Explore/model "MEP" enablers/barriers

Urban Science

Behavior & Decision Science

Photo Credit: Josh Sperling (in Columbus)

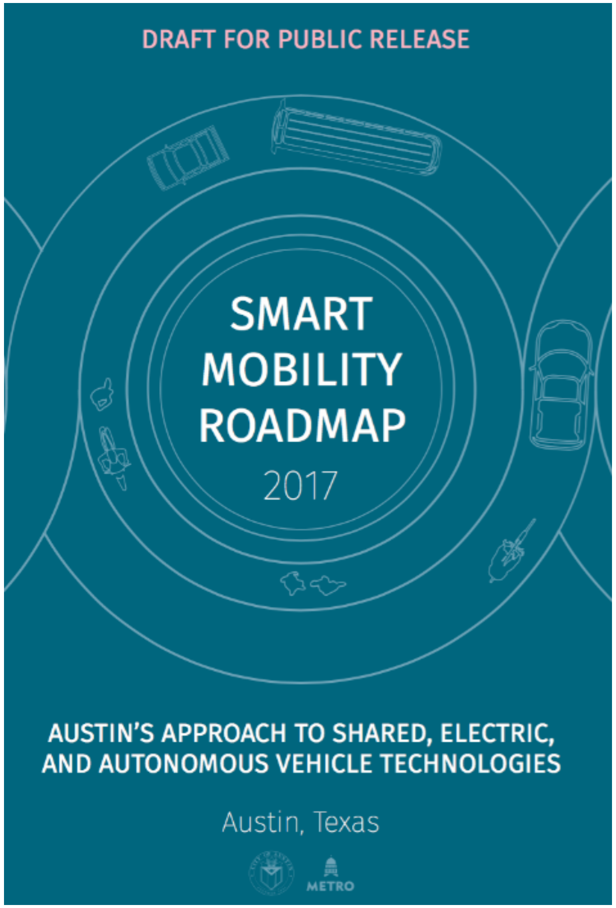
TNC: transportation network company, CAV: connected and autonomous vehicles, EV: electric vehicle

Relevance: Co-Design of Urban Science via Key Research Questions

Critical Research Questions

- **PEOPLE: How** does SMART-enabled mobility impact urban travelers; how travel is shifting/transforming in near to mid-term? **Why and where** MaaS may have greatest travel and energy impacts in near term?
- **INFRASTRUCTURE: What** are long-term impacts of SMART mobility on city infrastructures? **Where** are combined infrastructures/social structures enabling SMART mobility adoption, diffusion, upscaling, and public-private partnerships?
- **IMPACTS**: What will SMART mobility system impacts be on energy, travel, congestion, **parking**, and land use in cities? **When** are transitions/rates of change accelerated to automated-connected-electric-shared mobility in cities?

Integration of Data, High Performance Computing for Key Urban Mobility Hubs, and Data Stories / Visualization to Inform Planning & Decision-Making



Early Draft Roadmap Provided by Karla Taylor (City of Austin) & Karl Popham (Austin Energy)

HPC: high-performance computing

Milestones

Year	Description of Milestone or Go/No-Go Decision	Status
December 2016	• Assess the state of urban mobility modeling maturity and capability to reflect SMART mobility mega-trends • Engage practitioners, industry, academia, and researchers through a hosted workshop to benchmark existing practice • Convene workshops and develop key report for FY17 Q1. • Prioritize future investments in mobility model development	Complete
June – October 2017	• Curate Smart City partners transport models and data • Infuse new data as basis to exercise/advance urban models • Energy/urban travel impacts of SMART technologies/services.	Complete – new report
FY18/19	• **Advance** TNC/MaaS data collection & analysis at key mobility hubs – issue requests / collect data for Airport operations • **Diffuse** critical data, benchmark metrics, & track new mobility innovation-related behaviors using an NDA/MOU for collaboration with industry yearly urban survey • **Process** vehicle registration records from sample states **to leverage** new data integration, visualization, and analytical tools to accelerate planning and decision-making on urban futures.	On Track

Approach – Toward a Mobility Data Models Informing Smart Cities Report

Cross-Scale Actors & Institutions	Open Data Platforms	Key Smart City Indicators	Mapping Data & Models	City-Based Lit. Review & Reports

Dec. 2016: Columbus, OH

Feb. 2017: Portland, OR

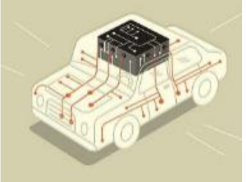
Apr. 2017: Pittsburgh, PA

May 2017: San Francisco, CA

Jun. 2017: Austin, TX

July, 2017: Denver, CO

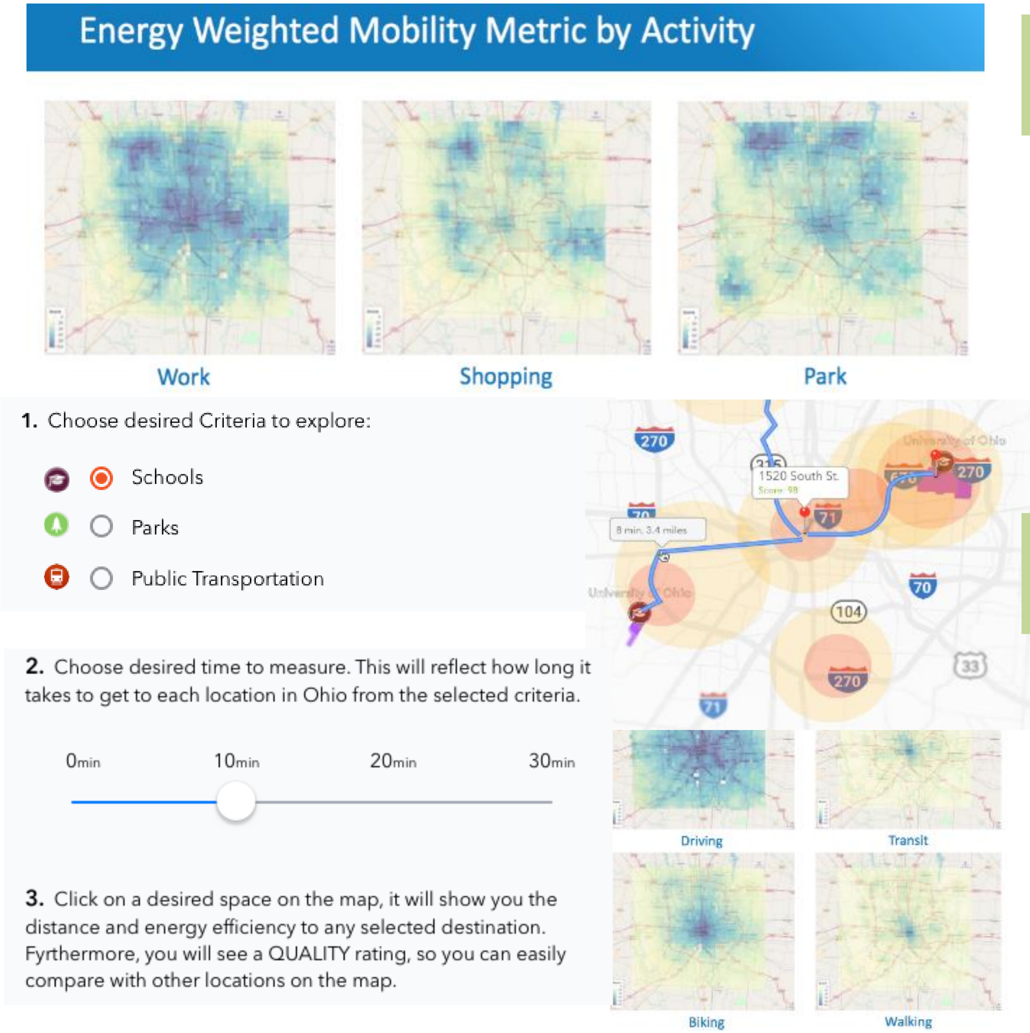
- Starting with 7 DOT Smart Challenge Finalists
- Capture Smart City objectives / work with partners
- Characterize data and modeling environments
- Harness Urban Data-Modeling Resources
- Enable/Validate/Benchmark Progress
- Upscale Smart City, Mobility, & Energy Innovation



NEW REPORT: Sperling, Young, et al. 2018. Evolving Mobility Data & Models Informing Smart City Mobility and Energy Goals.

RESULTS for each city contain:
- Each city's **priorities**, metrics, & key goals/pilots in mobility/energy spectrum
- Curating **mobility data** and analysis efforts supporting DOE/City initiatives
- Summarizing existing modeling capacity, **scenarios** and frameworks
- Key takeaways specific to each city for **energy-efficient mobility system** goals

Technical Accomplishments: Task 2.1 has spawned several activities



From Urban Data / Model Curation…to:

- 2.1.1: Data collection at key urban transportation hubs; on vehicle registrations; and city-by-city Mobility-as-a-Service dynamics
- 2.1.2: Mobility Energy Productivity
- 2.1.3: Austin Modeling

Key Opportunities:

Mobility Choice Blueprint

MAXIMIZE EXISTING INVESTMENTS IN OUR TRANSPORTATION SYSTEM BY LEVERAGING TECHNOLOGY TO PLAN FOR OUR FUTURE WORKFORCE AND EMPLOYER MOBILITY NEEDS AND INCREASE ECONOMIC OPPORTUNITIES AND QUALITY OF LIFE.

Developing Integrated Urban Data-Modeling Resources to Inform Urban Mobility

Technical Accomplishments: Curation Report

- **Full internal review complete and invited external reviews (including drafts shared with cities)**

Cross-City Comparison and Summary of Model Details	Columbus	Portland	Pittsburgh
Model Name	MORPC	Metro	SPC
4-Step (4S) /Activity-Based (AB)	AB	AB	4S
Static Assignment (SA) Dynamic Assignment (DA)	DA	DA	SA
Last Upgraded	2004	2010	2015
Next Upgrade	2017	??	??
TNC Mode Included? (Y/N)	N	N	N
Special Generator A- Airport, F- Freight, IE - Internal/External Trips U - University, O - Other	F, IE	A, F, IE	A, IE
Scenarios Considered/Tested I - Infrastructure D - Demographic L - Land Use EN - Energy EC - Economy T - Technology	I, D, T	I, D, L, EN, EC, T	I, L, EN, EC

New Inputs /Outputs for Energy Assessment:

Key needs: data collection at key mobility hubs; vehicle registrations; and MaaS by cities

Deeper Analyses of Columbus/Austin Data and Modeling Environments

Columbus, Ohio, New York, Colorado, California: Vehicle Registrations by Zip Codes for Urban Travel/Energy Models

Technical Accomplishments: Curation Report –Foundational Insights and Next Steps

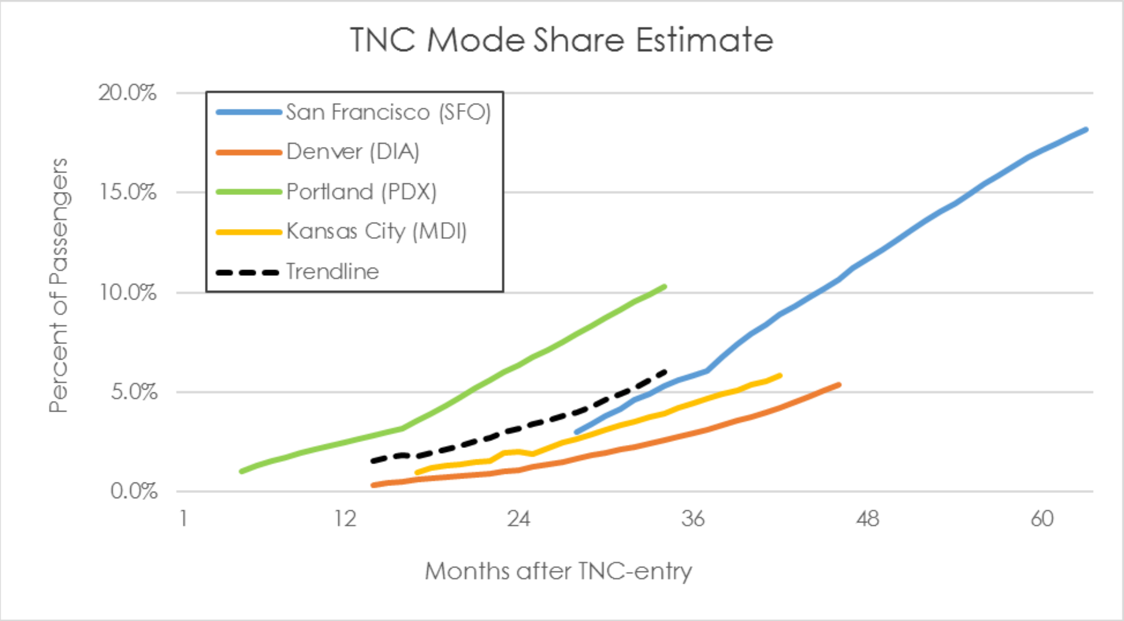
- As with previous challenges to transportation modeling, the ability for TDMs to reflect impact of emerging ACES mobility technologies lags in capability. Even with methodology advances over the past decade and a half that provide more sophisticated means to reflect travel behavior choices at the individual traveler level, even the most the most advanced urban models, such as the 3C model being deployed in Ohio, do not reflect, predict, or anticipate impacts from ACES mobility. Traditional TDMs are perceived primarily as roadway management and capital investment tools, and cities are looking more broadly for decision guidance with respect to emerging mobility trends.

- Given the fundamental gap in data, the lagging nature of TDMs and shortfalls in real-world automated mobility data in cities, near-term research priorities include continuous assessment and analysis of urban mobility data, specifically transportation network company uptake and utilization in cities, augmented with accessing state vehicle registration data to observe consumer behavior shirts, and coupled with advances in cross-city analyses.

Over all, this curation activity is intended to enable efficient access to the knowledge generated from Smart City peer cities, share knowledge and insights, and benchmark its progress. It also aids in continuing to identify gaps in knowledge and practice, which in turn will expose opportunities for the DOE SMART initiative to contribute and gain insight and access to valuable data from Smart City programs.

Technical Accomplishments: Task 2.1.1 Data Collection at Hubs

- **As a cross-cutting collaboration with task 2.2. in Mobility Decision Science**



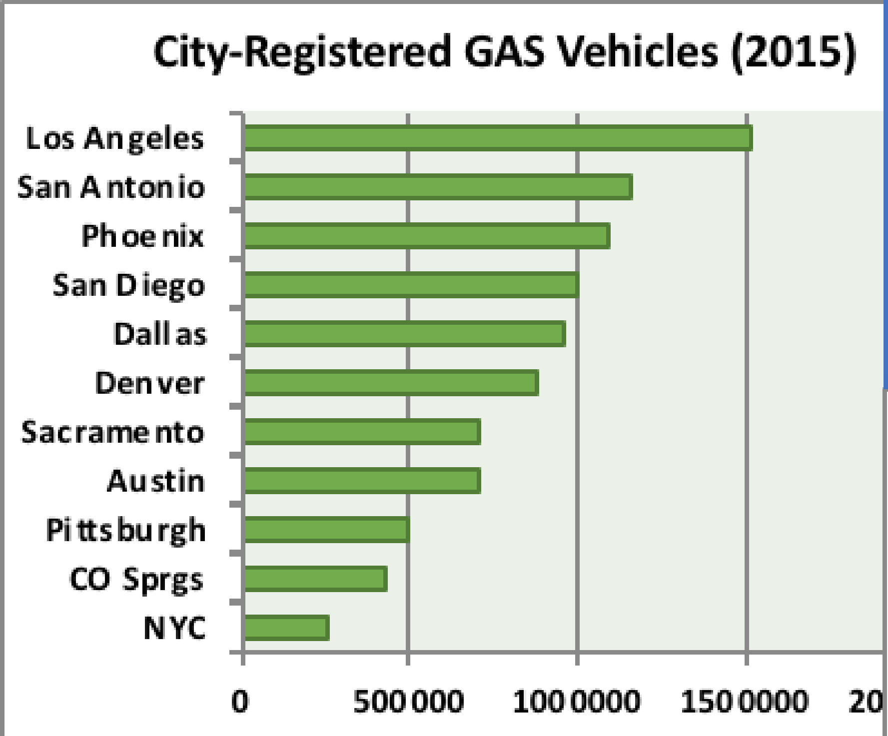
New ITS-America Paper by Sperling and Henao, 2018:

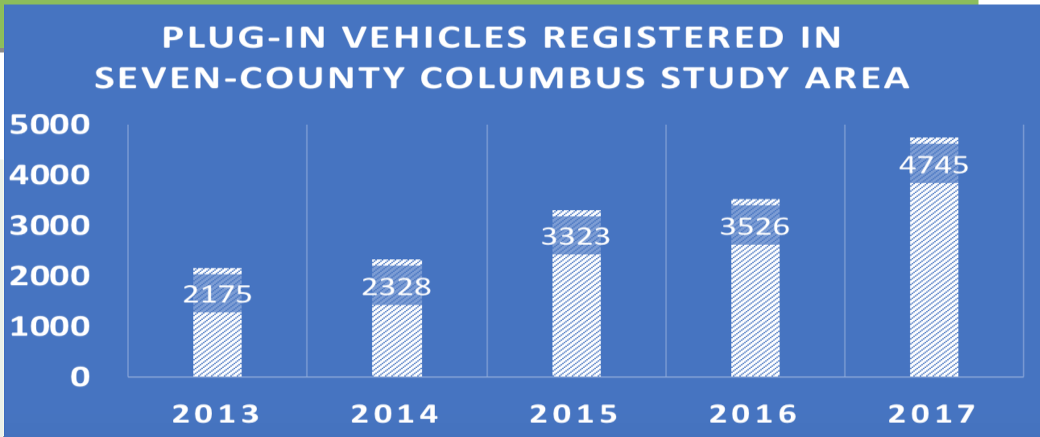
Cross-city airport analyses informing initial rates of smart mobility transitions: how quickly are we adapting to new energy-efficient mobility services? Are they more or less energy efficient?

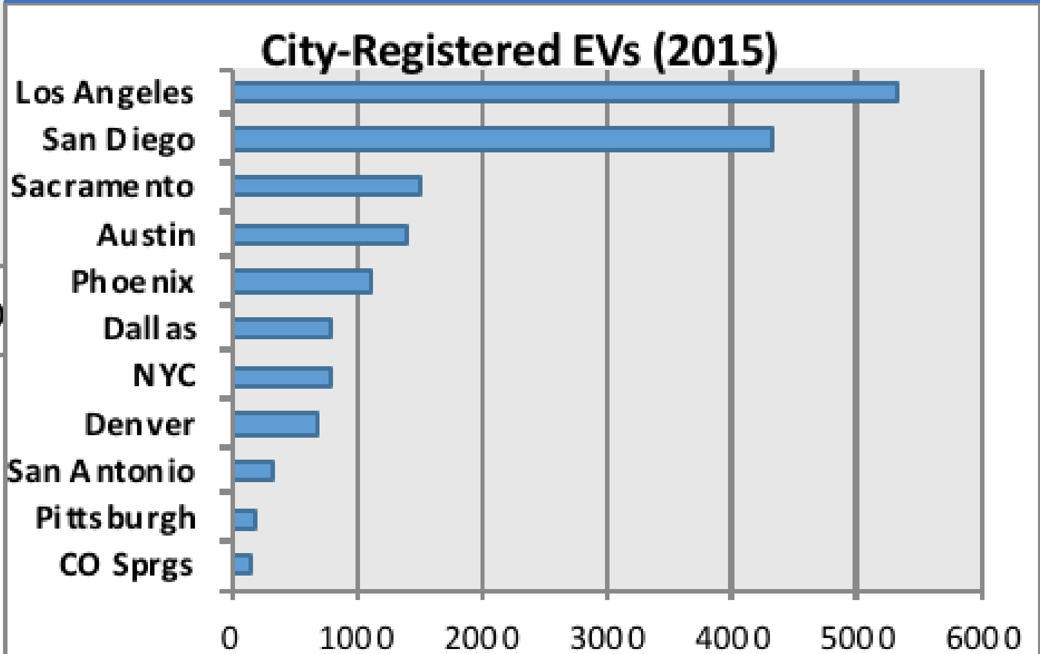
Notes:

- Mode shared estimate of total airport passengers (enplaned + deplaned)
- Percentage of connecting passengers unknown
- Conservative/low estimate (connecting passengers)
- SFO: $3.85 (July 2012), DIA: $2.15 (Oct 2013), PDX: $2 (Dec 2014), MDI: $3 pick-up only (May 2014)
- Vehicle Occupancy: 1.3

Technical Accomplishments & Progress: Vehicle registrations data







CA SB 1014 ZEV Amendment- 4.26.18:

By January 1, 2030, 100 % of the vehicles that are purchased, leased, owned, or contracted for by a transportation network company shall be zero-emission vehicles."

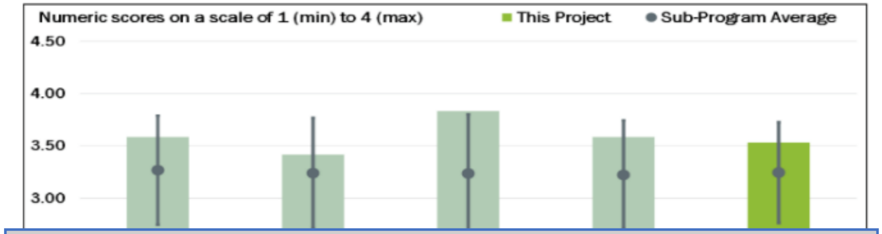
Technical Accomplishments & Progress: Collaboration with Strategic Vision on industry-supported Urban Mobility as a Service Surveys

- **Collaborations for annual data collection** with Strategic Vision and cities to help inform cities on MaaS / key mode shifts:
  - Identifying baseline characteristics of users of TNCs, carshare, bikeshare, and other services and tracking over time will help fill gaps in knowledge, existing datasets and models, and will be essential in future planning operations.
- *Key Challenge*: Most data collection for city or metropolitan planning purposes are performed on a sporadic basis, typically aligned with a major planning initiative.
- *Key opportunity*: introduce an industry supported, and consistent Smart City mobility survey, concentrated on Mobility as a Service trends that provide urban areas the latest information on citizens views, behaviors, and system-level impacts in this rapidly evolving space.

	2015 [% change from 2011]			2011		
City/Region [Avg Commute Time, mins]	**Drove Alone**	**Carpooled**	**Public Transit**	**Drove Alone**	**Carpooled**	**Public Transit**
City of Austin [23.4]	73.6 [2.45]	10 [-14]	4.2 [-11.9]	71.8	11.4	4.7
Austin metro [23.3]	71.9 [2.78]	10.5 [-13.33]	4.7 [-12.77]	69.9	11.9	5.3
City of Columbus [21.4]	80.2 [-0.75]	8.7 [4.6]	3.3 [9.09]	80.8	8.3	3
Columbus metro [21.1]	79.9 [-0.63]	8.5 [1.18]	3.3 [9.09]	80.4	8.4	3
City of Denver [24.8]	70.3 [1.42]	8.5 [-17.65]	6.8 [-10.29]	69.3	10	7.5
Denver metro [26.4]	75.7 [0.92]	8.9 [-11.24]	5.0 [-6.0]	75	9.9	5.3
City of Kansas City [21.6]	79.7 [-1.0]	8.9 [-2.25]	3.3 [-9.09]	80.5	9.1	3.6
Kansas City metro [21.3]	82.7 [-0.36]	8.8 [2.27]	1.8 [-5.56]	83	8.6	1.9
City of Pittsburgh [23.4]	55.7 [3.95]	9.3 [-9.68]	17.0 [-11.76]	53.5	10.2	19
Pittsburgh metro [26.1]	70.2 [1.28]	9.2 [-7.61]	10.2 [-6.86]	69.3	9.9	10.9
City of Portland [25.1]	57.8 [-3.98]	9.2 [-1.09]	12.10 [0.0]	60.1	9.3	12.1
Portland metro [24.8]	67.1 [-2.98]	9.7 [2.06]	8.4 [5.95]	69.1	9.5	7.9
City of San Francisco [31.7]	35.9 [-5.01]	7.3 [-6.85]	33.1 [1.21]	37.7	7.8	32.7
San Francisco metro [30.5]	53 [-3.77]	9.7 [-3.09]	20.8 [7.21]	55	10	19.3

Responses to Previous Year Reviewers' Comments

- 2nd highest scored of 22 EEMS presentations
- Critical need for DOE- + city-relevant metrics/ early-stage R&D/technical analysis/new city TNC-MaaS-EV-CAV data-driven urban models



- **AMR Review Comments**

APPROACH - an excellent approach by means of methods and analysis to gain understanding of the urban mobility space.

TECHNICAL ACCOMPLISHMENTS - understanding of methods used by each city is being developed. The reviewer stated this project reflects insights to a very complex set of problems in the space of urban science and mobility while realizing the relationship to behavior/decision science with urban mobility.

FILLING KNOWLEDGE GAPS - The reviewer remarked that understanding the nature of existing models and identifying/filling their gaps clearly has not been done before.

Future Research - The reviewer reported that the project is observing an extremely well-defined project plan to:

- Leverage data integration, visualization, and analytical tools to inform planning and decision making on urban futures;
- Curate transport models, and data with Smart City partners to include in a repository for urban mobility science and research;
- Extend data collection/analyses as a basis to exercise/advance urban models; & ID impacts of SMART technologies on urban travelers.

The reviewer observed that the PI recognizes the evolving effort presented by coordination of participant cities and development of data sets and models that will be useful across cities.

Collaboration, Coordination, and Co-Creation: Learning from Urban Data Science and Public-Private Partnerships (PPPs)

- DOE National Labs, Strategic Vision, Carnegie Mellon and working across Smart City Networks
- Smart City Finalists, their cities/MPOs, universities, transit agencies, MPOs, and MaaS providers
- Emerging Collaborations from DOE SMART Mobility workshops and Urban Data Science/Modeling
- Additional Data Curation across Large to Smaller U.S. Cities: e.g. Los Angeles, NYC, Dallas, Boulder

ENERGY EFFICIENT MOBILITY SYSTEMS- STRATEGY FROM AN URBAN SCIENCE PERSPECTIVE

VISION: An affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption (*with cities as frontlines of these transitions / transformations*).

MISSION: early-stage R&D at vehicle, traveler, and system levels; co-creating new knowledge, tools, insights, and technology solutions for **mobility energy productivity *(+ improved lives via new decisions / choices / opportunities for individuals, businesses, service designers/operators/users, to policy actors*)**

GOAL #1: Develop urban science tools, techniques, & core capabilities to understand & identify key levers (e.g. developers, parking, right-sizing on-demand transit) to improve the energy productivity of integrated future urban mobility systems; and upscale/diffuse + urban (r)evolutions via objective data and insights.

GOAL #2: Early stage R&D and a new joint urban innovation co-laboratory & exchange (JUICE) on mobility/ energy **technologies/ services** that enable better futures.

STRATEGIC GOAL #3: Co-create research insights by coordinating /collaborating with PPPs **to support energy efficient local-regional-state-national-global transportation systems.**

Remaining Challenges and Barriers: Data, Data, Data - Upscaling Urban Data Integration for Assessment and using new Emerging Data & Models

- **Data/models keeping up with reality; inputs to/outputs from integrated energy assessment**

Freight & Goods

Airline Travel

Commuter

Proposed Future Data Collection, Analysis and Research: FY18/19

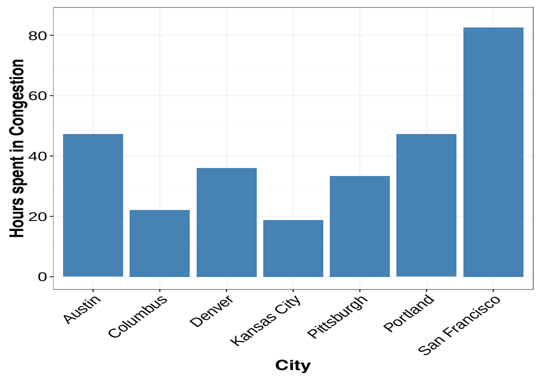
- **Integrated Data:**
  - Parking, and at key mobility hubs – continuing data collection at airports, CBDs, universities; using apps
  - State vehicle registration databases to characterize mobility/energy dynamics at city and county levels
  - industry (Strategic Vision) partnership: MaaS in cities
- **Key Research Questions:**
- How connected, automated, shared mobility, and electrification technologies and on-demand services impact the urban network/traveler and urban systems? Key levers – e.g., commuting?
- How will SMART-enabled mobility impact the urban traveler in terms of VMT, congestion, vehicle ownership, MaaS?
  - What are short- vs long-term impacts on the urban built environment?
  - What are energy impacts of mobility innovations/ district-scale experimentation on new choices?

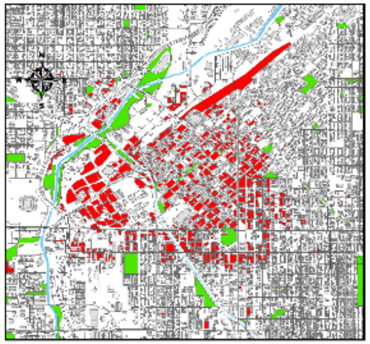
Hyper-Focus on Data for Key Mobility Hubs/ Services and ‘Occupancy’ Dynamics in Cities

Filling Key Data Gaps with new methods/models

Vehicle Registrations

SMART Mobility Data & Model Development Informing Cities (e.g. Goal: 10 to 20% increase in PMT/VMT)



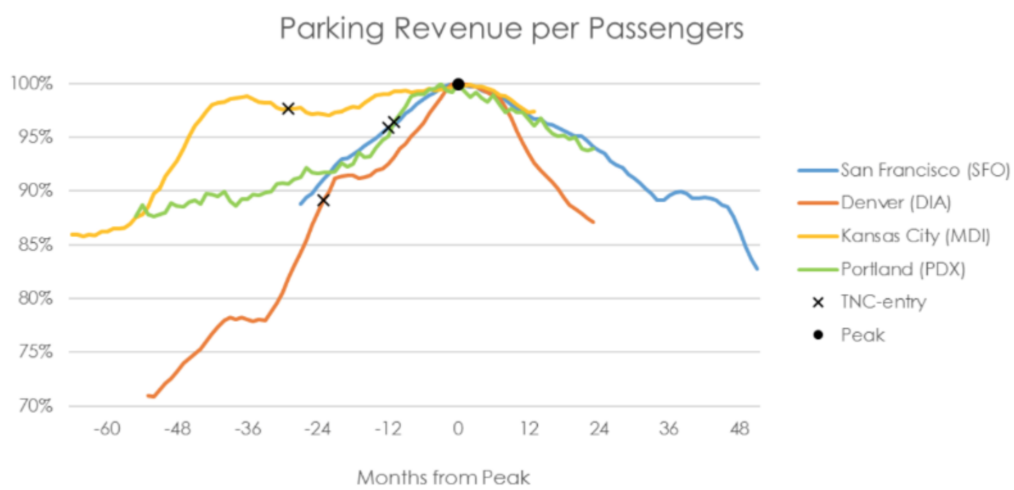


[Note: any proposed future work is subject to change based on funding levels.]

Summary

- DOE SMART Mobility Urban Science Efforts are helping:
  - Use/develop key data sets, models, and roles for DOE in engaging across 7 Smart City Finalists + for ensuring useful/useable insights
  - Target Austin opportunity (model and data maturity) for analyses
  - Feed/support other Urban Science/broader SMART initiatives

<u>ADVANCING THE FUTURE OF ENERGY EFFICIENT MOBILITY SYSTEM AND SERVICES FOR PEOPLE IN CITIES</u>



Opportunities: Exploring How Less Parking, New Land Use and Transportation Integration, Employer-based Commuting Programs in Cities, and Integrated ('Seamless') Payment Impacts on Energy Efficient Urban Mobility?

Thank you! Questions?
Joshua.Sperling@nrel.gov